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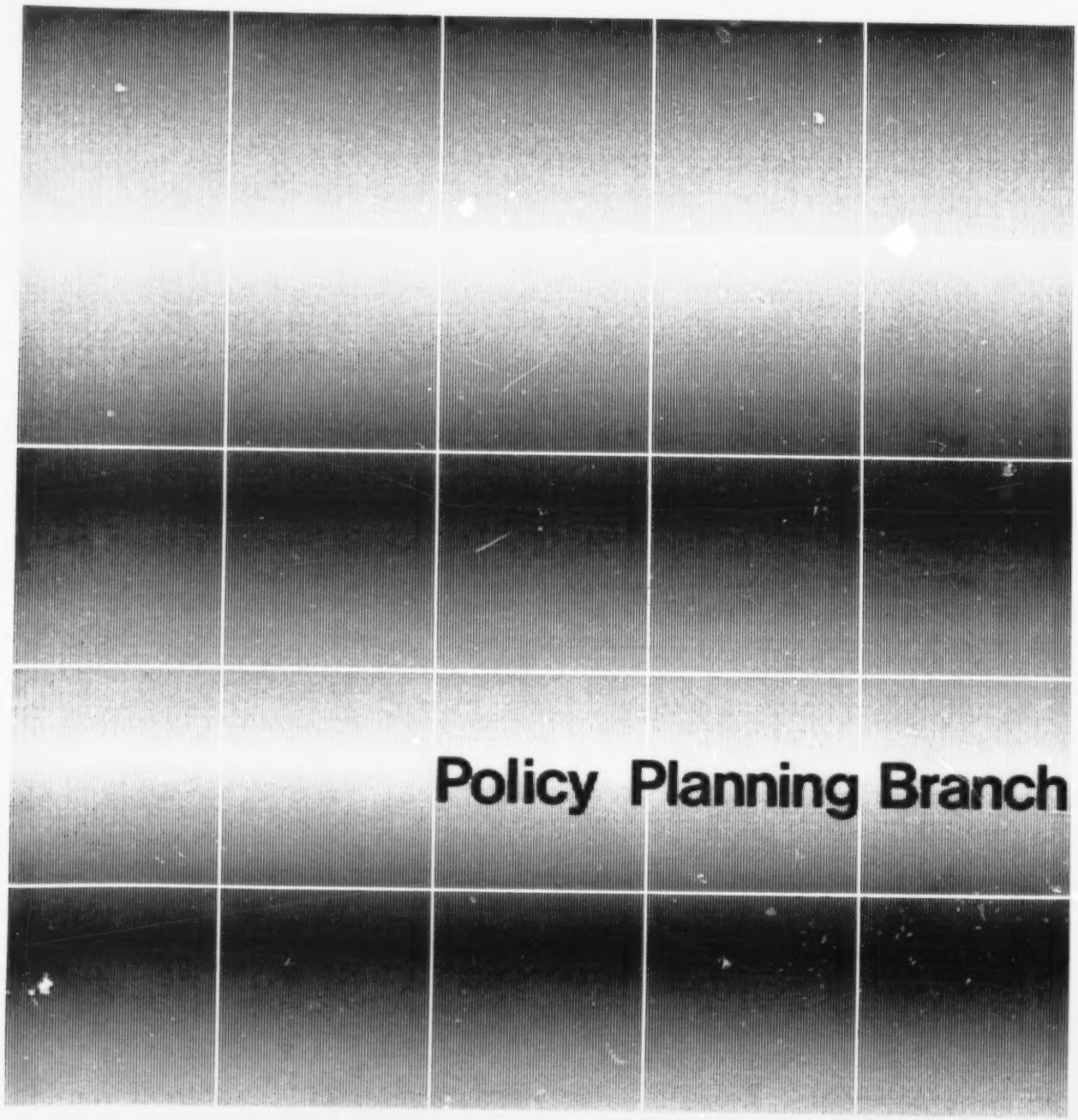

Policy Planning Branch

The Licence Plate Photo Technique

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TDF-81-02

The Licence Plate Photo Technique as Applied to Truck Origin-Destination Surveys

Max Perera
Gary Corupe
Transportation Planners
Transportation Demand Forecasting Office

Published by:
The Policy Planning and Research Division
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

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1/ INTRODUCTION

1.1/ General

The forecasting of future travel demands as part of the transportation planning process relies heavily on the determination of current travel patterns. This is achieved by the collection and analysis of origin-destination and socio-economic data. Home interviews and roadside interviews are the conventional methods of travel data collection. However, roadside origin-destination surveys are, for reasons of safety, considered undersirable for application on multi-lane, high volume highway facilities.

Since 1977, several origin-destination surveys of passenger vehicles on multi-lane highways in the province have been conducted using the licence plate photo technique.

The technique involves the photographing of a specific sample of the vehicles passing the survey location, the matching of vehicle licence plate numbers to registered owners, and the surveying of owners through the use of a mail-back questionnaire.

The present study is aimed at testing the suitability of the licence plate photo technique to survey truck travel on Highway 401 through Metropolitan Toronto. In November 1980, the technique was applied for the first time to study the travel pattern and characteristics of truck movements at a selected survey location.

1.2/ Study Background

The application of the licence plate photo technique to survey truck travel on Highway 401 was suggested by Mr. Ven Chi Ma. Accordingly, the survey was staged on Tuesday, November 25, 1980, and was aborted due to bad weather and blowing snow. Another attempt was made on Wednesday, November 26, and the survey proceeded smoothly from the Keele Street overpass between the hours of 10:00 and 15:00. A report of the weather conditions on the two days is shown in Appendix D.

Figure 1 shows the location of the survey site within Toronto. The site was chosen primarily for its administrative convenience. Further, the traffic at this location is considered typical of the high volume traffic across Toronto. The cameras were positioned on the Keele Street overpass because adequate coverage of the required eastbound lanes was not possible from locations on the shoulder. The Highway 401 lanes surveyed are depicted in Figure 2. The survey was confined to four of six truck travel lanes in the eastbound direction as there were only four cameras available. Being the first photo-licence plate origin-destination survey of truck travel it was decided to photograph as many trucks as possible since no typical response rates were known for the Province of Ontario. Response rates for licence plate surveys of passenger vehicles carried out to date in the Province are between 50.7% and 55.2%. The 12 h (07:00 - 19:00) one way truck traffic on Highway 401 at Keele was estimated at about 8000 A.A.D.T.

The hourly distribution of truck traffic (both directions) at the Keele Street P.C.S. for a day in June 1978 is shown in Appendix A.

1.3/ Need for Truck Survey Information

Truck travel data on the Ontario provincial highway system is an important consideration in the implementation of new policies and facilities within the system. It is particularly related to the following purposes:

- o geometric design;
- o pavement and structure design;
- o traffic operation and capacity;
- o traffic safety and regulation;
- o long-range and priority planning; and
- o environmental studies.

At the present time, one of the critical problems in travel demand forecasting is the lack of the capability to forecast future truck demand on the highway system, whether in an intercity or urban goods context. Generally speaking, there is not even an adequate data base upon which to build forecasting capability.

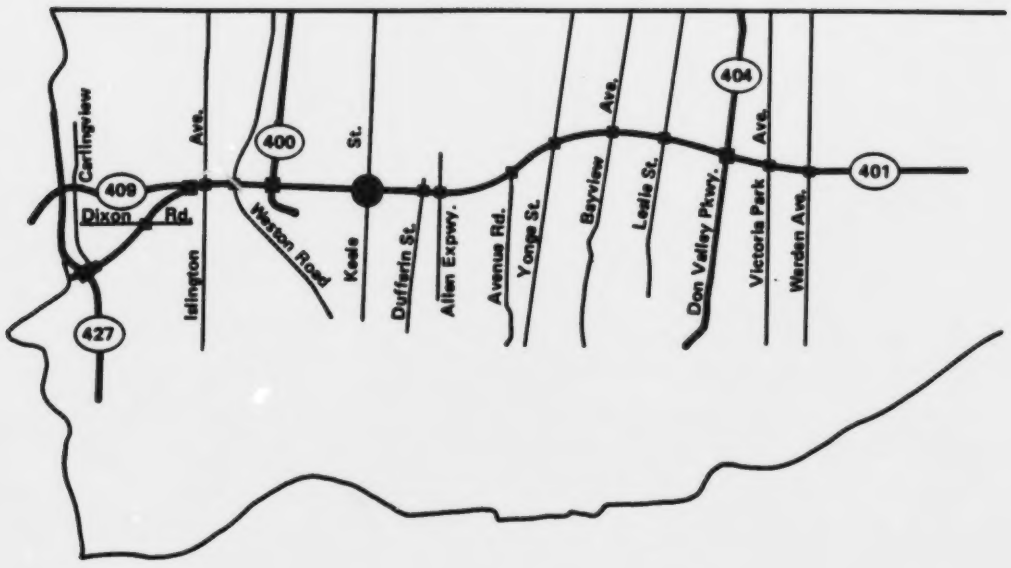


Figure 1/ Location of Survey Site

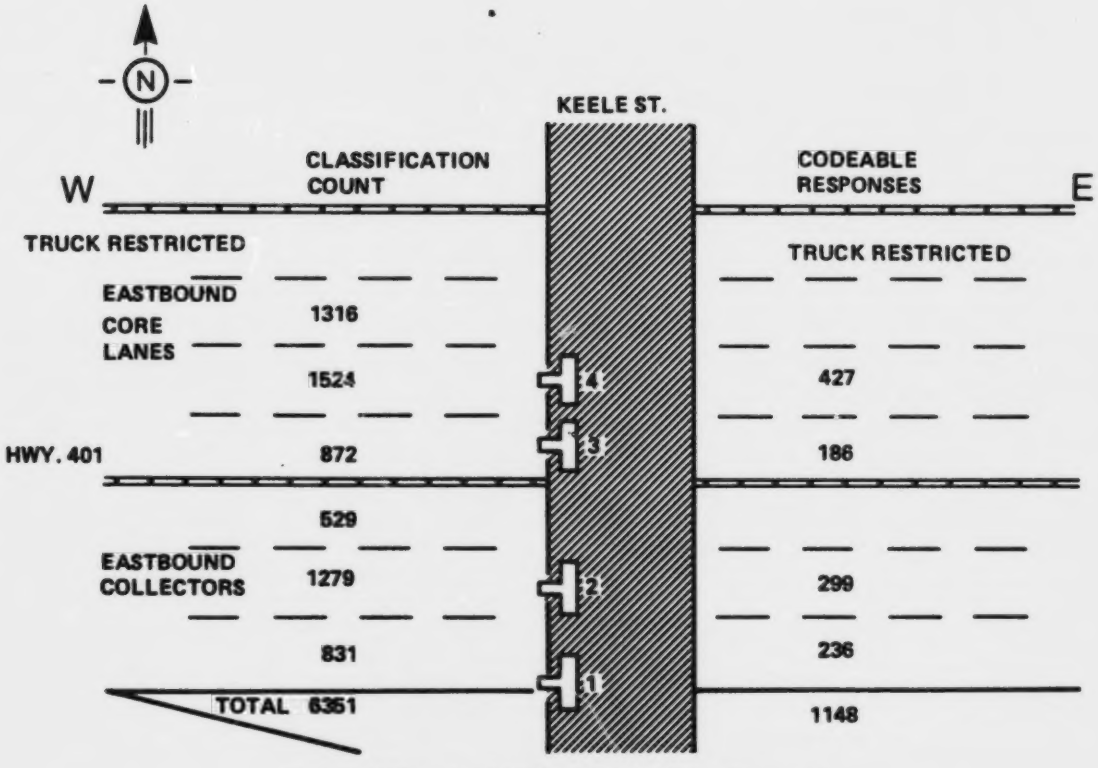


Figure 2/ Sketch of Highway 401 Lanes Surveyed

Should this technique prove feasible it could be applied at several strategic locations on the freeway system to assemble a composite truck travel pattern on multi-lane highways near major metropolitan areas. This pattern may be supplemented with other origin-destination data collected from roadside surveys to construct a total truck travel pattern for the provincial highway system.

The technique could also be applied to more specialized studies, such as the monitoring of major highway access points or major travel demand generators, without impeding the normal flow of traffic.

This report documents the technique used, statistics obtained from the survey, and provides an analysis of the data collected in the licence plate photo origin-destination survey of truck travel on Highway 401. The survey was conducted in Toronto on November 26, 1980.

1.4/ Purpose of Survey

The prime purpose of this project was to test the suitability of the photo-licence plate method for collecting travel data relating to commercial vehicles on multi-lane highway facilities in Ontario. Some of the specific objectives of this survey are as follows.

(a) Test response rates of truck owners

The existing available data is only for auto respondents. Response rates yielding codeable questionnaires for the surveys conducted in Toronto so far have been between 22% and 43%.

(b) Test usefulness of requesting intermediate stop information

Trucks are known to stop for deliveries and pick up several times on peddle runs. Some idea of the occurence of peddle runs was desired.

(c) Entry-exit patterns at selected interchanges was requested by the Traffic Office

The Traffic Office was desirous of understanding the truck traffic patterns on the core and collector lanes between Highway 427 and Warden Avenue. This information was to be used in the Traffic Management System.

(d) Test for possible bias

A lower response than for passenger vehicles was expected. Response rates for the different truck categories were expected to be different.

These objectives are addressed in Chapter 4. It is anticipated that further results will be presented in a future report of a similar truck survey to be carried out for a 12 h period in August 1981.

2/ SURVEY PROCEDURE

2.1/ General Methodology

The licence plates of the trucks travelling on two core lanes and two collector lanes of the highway were photographed from the Keele Street bridge. The plates were read from the processed film using a Recordak film viewer. The licence plate numbers, together with a lane number and time segment, were keypunched (transferred) onto computer cards. These cards form the input to the computer program that searched the Master Vehicle File. Given a licence plate, it prints the name and address of the registered owner of the truck on an adhesive address label. A mailback questionnaire, together with a return mail envelope, was posted to each registered owner so identified from the photographic film by Friday, November 28, 1980. It was thought desirable to get the questionnaires to the recipients as quickly as possible while the trip particulars were still fresh in their minds.

2.2/ Photographic Equipment

Canon F-1 cameras with 250-exposure backs and motor drives were used in photographing the truck traffic. The pictures were obtained under shutter speeds ranging from 1/500 to 1/1000, depending on light conditions. A 135 mm telephoto lens and Kodax Plus X medium speed black and white film with an ASA rating of 125, pushed to 250 ASA in processing, was used with each camera. The shutter speeds, lens, and film type used were established in tests conducted before the initial automobile licence plate survey in 1977.

2.3/ Questionnaire Design and Public Participation

The questionnaire, addressed to truck owners, requested information on run origin and destination, listing of intermediate stops, points of entry and exit from Highway 401, and whether the truck was for hire or otherwise. The Ontario Trucking Association was consulted on the questionnaire format. The Association offered valuable advice and lent further support for this survey by publishing details in their "Round-up" news bulletin of November 17, 1980, under the caption "MTC TO CONDUCT SPOT AND CONTACT HIGHWAY USE SURVEY ON 401". The news release outlined the reason for conducting the survey and the method of data acquisition.

The date of the survey was left vague, so as not to disrupt the normal travel patterns. The covering letter and the questionnaire itself are shown in Appendix B and C, respectively.

2.4/ Planning and Organization

The detailed planning and organization of the survey, involving many people and offices, was left in the hands of Gerry Warner, Traffic Characteristics Office, MTC. For details of the organizational aspects of licence plate surveys, please refer to "Origin-Destination Survey Report 1979" by B. Bigrove, Traffic Characteristics Office, MTC.

2.5/ Weather

The conditions existing were not the best for an outdoor survey. Environment Canada provided the following information regarding prevalent weather conditions in the general area of the survey:

Temperatures	Minimum: -2.5°C
	Maximum: -1.3°C
Wind Speed	10 - 13 knots (N.W.)
Precipitation	None
Sky Condition	Scattered clouds at 1100-1600 feet above ground
Cloud Amount	80 - 100% of sky obscured.

For additional details of weather see Summary Environment Canada report, Appendix D.

2.6/ Photographing Truck Licence Plates

The field staff manning the four cameras attempted to record the licence plates of as many trucks as possible travelling in the four eastbound lanes. The survey was conducted between 10:00 and 15:00. Figure 3 shows camera positions on the Keele Street overpass.

The licence plates of about 3800 trucks were captured on film. During the survey period, however, about 4500 trucks passed through the station on the four lanes in question. The approximately 700 other plates were missed largely due to the time taken in unloading and reloading the cameras after every 250 exposures. A classification count of trucks on all lanes for the survey period recorded nearly 6350 trucks.

The film was exposed manually when a truck passed a focus point on each lane. On complete exposure of the film it was unloaded, labelled as to lane number and time segment (hour of the day), and dispatched for processing. The unloading, reloading, and focussing process takes about 60 s on average.

2.7/ Film Processing

The exposed films were developed in the Ministry's Audio Visual Section and processing time was about four hours.

2.8/ Data Transfer (Keypunching)

It was important to get the mail-back questionnaire to the registered truck owners without delay so that they could respond to it while the trip details were still fresh in their minds. The developed films were viewed through Recordak film readers (see Figure 4). Keypunching of licence plates from the film under some time constraint yielded 3472 data cards. One data processing card was punched for each truck licence plate. The data card recorded the licence plate number, the lane number, and time of day by the 24-hour clock. The keypunching operation involved two operators: one to manually advance the film, the other to keypunch the licence plate as seen in the reader. Both operators read the number loud enough to be heard by the other to ensure that the plate identification was correct. The entire process involved 14 person-hours of work. The cards were not verified.

2.9/ Review and Subsequent Verification

A review of the films and verification of the keypunched cards produced 3607 data cards, which represent 135 additional cards and 142 cards that had initially been incorrectly keypunched. Effectively, the verification process yielded 277 more valid data cards (an 8% increase), at the expenditure of an additional 16 person-hours of work.

The data entry operators could not extract the licence plate numbers of some vehicles, because the plates were dirty (123 trucks) or were not visibly mounted on the front of the vehicle (11 trucks). A number of out-of-province vehicles were also identified (59 trucks).

Figure 3/ Camera Position on the Keele Street Overpass

Figure 4/ Viewing Film on a Recordak Reader and Keypunching Licence Plate Number

2.10/ Vehicle File Search

The computer data cards were read into an IBM 2501 card reader. The search program compared the licence plate number from an input data card with the Master Vehicle File. When a match occurred the truck owner's name and address, along with the licence plate number, were placed in a tape file. The Master Vehicle File is comprised of over 9.5 million records which are stored on disc files for ease of access. Processing of 3400 records took less than fifteen minutes. In all, 3234 address labels were created from matching licence plates. The following losses were noted:

- o licence plates not found on the vehicle file, 223, mainly those of new vehicles not on file and some as a result of keypunch errors;
- o out-of-province licence plates, 12;
- o cancellations and unfit transfers, 3.

Each address label had the vehicle plate number printed on the top right-hand corner.

2.11/ Mailing

The self-adhesive address label was manually placed on an envelope, and the licence plate number was transcribed onto the questionnaire; together with the covering letter and a mail-back envelope it was mailed to the registered owner. All questionnaires were posted by Friday, November 28, 1980. Costs totalled 17¢ to mail each questionnaire and 20¢ when a reply was received, all by First Class mail.

2.12/ Coding and Data Storage

Detailed coding instructions for the survey are shown in Appendix E. Origin and destinations were coded to the Provincial zone system as well as the 1979 TARMS zone system. The last four digits refer to the TARMS zone and the first six digits indicate the Provincial Zone. The coded survey data are on tape

DSN = TCMP.JH605022 and VOL/SER = 022038

RECFM = FB

LRECL = 160

3/ INFORMATION RETRIEVAL FROM MASTER VEHICLE FILE

3.1/ General

To keep the questionnaire simple it was decided that information already on record in the Ministry data files would be used. In this study the following data pertaining to each vehicle record was extracted from the Master Vehicle File and copied onto each survey record.

(a) Body Type
(b) Number of Cylinders
(c) Motive Power
(d) Number of Axles

The data relevant to each survey record were lodged in the following format.

Information	Character	Record Column
(a) Body Type	Alpha	156 - 157
(b) No. of Cylinders	Numberic	158
(c) Motive Power	Numeric	159
(d) No. of Axles	Numeric	160

Extraction of data from the Master Vehicle File was carried out by the Vehicle Systems Office of the Computer Systems Branch.

3.2/ Data Conversion

To facilitate use of existing computer programs in the analysis process it was necessary to convert the Body Type field from alpha to numeric characters.

Numeric codes equivalent to the alpha characters representing the different categories of Body Styles are given in Appendix F.

4/ RESULTS AND ANALYSIS

This chapter presents statistics pertaining to the sample surveyed. Characteristics of the survey truck population and the characteristics of the vehicles whose owners have responded positively to the questionnaire are presented for comparison.

Travel patterns of the highway users and other useful indicators such as average trip length distances for different categories of truck users will be presented in the ensuing sub-sections.

4.1/ Response

The overall response rate for the survey was slightly in excess of 50%. Nearly 31% of these responses were received during the first five working days after mailing. Responses received in the second and third week were 43% and 13%, respectively. An additional 13% of the responses were received between the fourth week and the cutoff date of February 6, 1981. Responses are still trickling in. Figure 5 indicates the rate of receipt of responses.

Of the 1691 respondents, 1163 provided a YES answer to the primary question about whether the vehicle registered under their name was at the survey location on the date in question, and also completed all other parts of the questionnaire.

Hence, the overall response rate is actually about 52.5%, and the codeable response rate is 34.5%. Analysis revealed that the percentages of completed questionnaires for those trucks travelling in the collector and core lanes were 31.9% and 37.2%, respectively. A tabulation of response categories is given in Table 1.

The number of respondents supplying codeable answers to the different questions in the questionnaire are listed below.

Q.1 Was vehicle on Highway 401 at Keele	- 1163 (yes)
Q.2 Was the vehicle for hire or private	- 1144
Q.3 Origin of run (trip)	- 1147

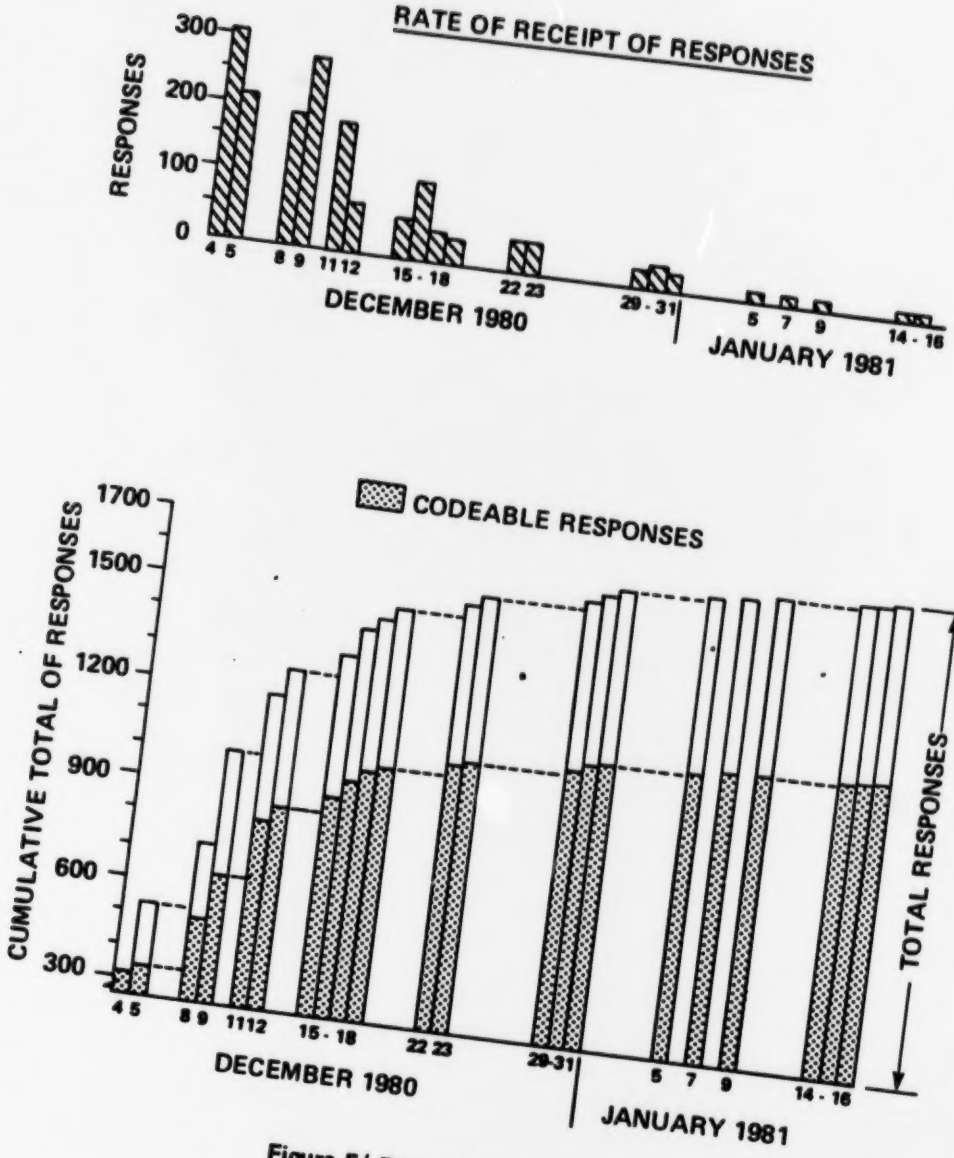


Figure 5/ Rate of Receipt of Responses

Table 1/ RESPONSE TYPE BY STATIONS

		COLLECTOR LANES		CORE LANES		TOTAL
STATION		1	2	3	4	TOT. %
"YES"		237	302	190	434	1163
(Row %)	R	20.38%	25.96%	16.33%	37.32%	
(Column %)	C	66.57%	63.98%	74.51%	71.38%	68.7%
"NO"		80	111	42	108	341
	R	23.46%	32.55%	12.32%	31.67%	
	C	22.47%	23.52%	16.47%	17.76%	20.2%
NEITHER		39	59	23	66	187
"YES"	R	20.85%	31.55%	12.29%	35.29%	
NOR "NO"	C	10.96%	12.5%	9.02%	10.86%	11.1%
TOTAL		356	472	255	608	1691
TOT. %	R	21%	27.9%	15.1%	36%	
PLATES BY STA.		701	990	528	1148	3367*
		20.8%	29.4%	15.7%	34.1%	

R = Row % C = Column %

* This figure includes a small percentage (about 4.0) of plates that are in error.

Q.4 List intermediate stops	
Stop 1	- 287
Stop 2	- 205
Stop 3	- 134
Stop 4	- 83
Stop 5	- 42
Stop 6	- 19
Q.5 Destination of run	- 1147
Q.6 Entry to Highway 401	- 1147
Q.7 Exit from Highway 401	- 1147

From the above tabulation it is seen that the number of blank replies was low for all questions, except that which called for a listing of the intermediate stops. One out of four "YES" respondents listed the intermediate stops. The relative mix of vehicles by body types in the category that listed at least one intermediate stop is shown in Table 2. As expected, a high proportion of stake trucks, vans, tankers, and tractors are on peddle runs (i.e. stops for delivery and pickups).

An analysis of a sample of questionnaires listing intermediate stops indicates that such stops have been listed without due regard to the order in which they were made. The travel patterns do not appear to be sensible and the value of this data is in doubt. No further analysis of this data will be carried out in light of these inconsistencies.

4.2/ Mix of Body Styles

Of the truck population through this location, 36.2% were vans, 35.6% were tractor units, and 14.6% were pick-up trucks. Codeable questionnaires from heavy trucks (i.e., types such as tractor trucks, stake trucks, tankers, and flat-beds, having the greatest impact on highway traffic) comprise about 40% of the group population. The response rate from dump truck, pick-up, and van owners, which is lower than the overall sample rate of 34.1%, is about 30% of their group population. Mix of body styles in the survey population and the category of respondents providing a completed questionnaire is given in Table 3.

Table 2/ RESPONDENTS LISTING AT LEAST ONE INTERMEDIATE STOP-
CATEGORIZED BY BODY STYLES

	YES RESPONDENTS			% on	Total
Body Type	Collectors	Core Lanes	Total Column %	Codeable Response	Codeable Response
Bus	1	1	2 0.7%	50%	4
Box	3	1	4 1.4%	66.6%	6
Dump	-	1	1 0.35%	3.7%	27
Flat Bed	4	2	6 2.09%	27.3%	22
Pick-up	10	9	19 6.62%	12.1%	157
Stake	5	10	15 5.23%	31.9%	47
Tanker	1	-	1 0.35%	12.5%	8
Tractor	43	60	103 35.89%	21.8%	472
Tow	-	-	-	-	4
Van	68	56	124 43.21%	34.6%	358
Other	6	3	9 3.14%	40.9%	22
None Above	2	1	3 1.0%	17.6%	17
	143	144	287	-	1145

Table 3/
RELATIVE BREAKDOWN BY VEHICLE BODY TYPES IN THE SURVEY POPULATION AND THOSE PROVIDING A COMPLETED QUESTIONNAIRE

Body Types		QUESTIONNAIRE Completed Codeable Responses	QUESTIONNAIRE Uncompleted Non-Codeable Responses	Survey Population
	R	25.0	25.0	
Bus		4	4	16
	C	0.4	0.7	0.5
	R	20.0	23.3	
Box		6	7	30
	C	0.5	1.3	0.9
	R	29.3	14.1	
Dump		27	13	92
	C	2.5	2.4	2.8
	R	38.6	15.8	
Flatbed		22	9	57
	C	1.9	1.7	1.7
	R	32.1	16.9	
Pick-up		157	83	490
	C	13.7	15.3	14.6
	R	40.9	16.5	
Stake		47	19	115
	C	4.1	3.5	3.4
	R	72.7	-	
Tanker		8	-	11
	C	0.7	-	0.3
	R	39.5	14.3	
Tractor		472	171	1195
	C	41.2	31.4	35.6
	R	26.7	13.3	
Tow		4	2	15
	C	0.4	0.4	0.5
	R	29.4	17.9	
Van		358	218	1216
	C	31.3	40.0	36.2
	R	32.8	11.9	
Other		22	8	67
	C	1.9	1.5	2.0
None	R	32.0	18.9	
Above		17	10	53
	C	1.5	1.8	1.6
		1145	544	3357
		34.1%	16.2%	100%

R = Row % C = Column %

4.3/ Motive Power

The ratio of gasoline to diesel-powered trucks is about 7:3 in the survey population. Only two propane-fuelled trucks were recorded.

A stratification of the survey population by body styles and motive power revealed that about a third (34.3%) were gasoline-powered vans and about a quarter (23.4%) were diesel-powered, tractor-type trucks (see Table 4).

A similar stratification was carried out on the codeable responses as shown in Table 5. The mix of gasoline to diesel trucks for this group was 2:1. In comparison with the mix for the survey population the response from diesel powered truck owners was slightly better.

4.4/ Entry-Exit Patterns

Considering the truck traffic on Highway 401 passing Keele Street, the heavily used interchanges for entry onto the highway are Highway 400 (20.7%) and Highway 427 (21.9%). Don Valley Parkway/Highway 404 (15.2%) and Dufferin Street (11%) are the two heavily used interchanges for exiting (see Table 6). Nearly 40% of the truck respondents have either one end or both trip ends using an interchange listed in the questionnaire. A system diagram for flows entering and leaving the highway is shown in Figure 6.

Entry-exit patterns relevant to the core and collector lanes are given in Tables 7 and 8. The separate tabulations for core and collector lane entry-exit patterns indicate that about 30% and 55% of the respondents travelling in the two lane categories have either one end or both trip ends using interchanges referred to in the questionnaire.

As the Keele Street Interchange was not included in the entry-exit pattern, the above information should be used with caution.

Table 4/ BODY STYLES BY MOTIVE POWER (SURVEY POPULATION)

	MOTIVE POWER				
	ELECTRIC	GAS	PROPANE	DIESEL	TOTAL %
Bus		16			16
		0.48%			0.48%
Box		26		4	30
		0.77%		0.12%	0.89%
Dump		51		43	94
		1.51%		1.28%	2.79%
Flat Bed		41		16	57
		1.22%		0.47%	1.69%
Pick-up		488	2	1	491
		14.5%		-	14.60%
Stake		99		16	115
		2.94%		0.48%	3.42%
Tanker		8		3	11
		0.24%		0.09%	0.33%
Tractor		409		787	1196
		12.15%		23.4%	35.55%
Tow Truck		12		3	15
		0.35%		-	0.45%
Van		1155		64	1219
		34.33%		1.9%	36.24%
Other		24		43	67
		0.71%		1.27%	1.99%
None Above		39		14	53
		1.15%		0.41%	1.58%
TOTAL		2368	2	994	3364
%		70.39%	0.06%	29.55%	

NOTE: All percentages are based on survey population (3364).

Table 5/ BODY STYLES BY MOTIVE POWER (CODEABLE RESPONSES)

	MOTIVE POWER				
	ELECTRIC	GAS	PROPANE	DIESEL	TOTAL %
Bus		4			5
		0.35%			0.35%
Box		5		1	6
		0.43%		0.09%	0.52%
Dump		14		14	28
		1.22%		1.22%	2.44%
Flat Bed		16		6	22
		1.39%		0.53%	1.92%
Pick-up		157	1	-	158
		13.68%			13.78%
Stake		43		4	47
		3.7%		0.4%	4.1%
Tanker		5		3	8
		0.43%			0.7%
Tractor		148		324	472
		12.9%		28.25%	41.15%
Tow Truck		4		-	4
		0.35%			0.35%
Van		338		21	359
		29.47%		1.83%	31.3%
Other		12		10	22
		1.04%		0.87%	1.92%
None Above		12		5	17
		1.04%		0.43%	1.48%
TOTAL		758	1	388	1147
%		66.09%	0.09%	33.83%	100%

NOTE: All percentages are based on codeable responses (1147).

Table 6/
ENTRY-EXIT PATTERN (WITHOUT FACTORS)
(Collectors and Core Lanes Combined)

	Hwy 400	Weston Road	Islington	Hwy 409	Dixon Road	Carlingview Drive	Hwy 427	Other	Total %
Dufferin	28	7	8	19	4	1	29	30	126 11%
Allen Expressway	28	8	7	7	3	-	15	17	85 7.42%
Avenue, Yonge	24	6	4	14	-	1	9	30	88 7.69%
Bayview	7	6	1	6	2	-	7	8	37 3.23%
Leslie	5	5	1	2	3	-	5	14	35 3.06%
Don Valley/ Highway 404	43	14	9	19	3	5	34	44	174 15.20%
Victoria Park	6	2	3	5	2	-	9	10	37 3.23%
Warden	18	5	4	9	4	-	9	25	74 6.46%
Other	75	22	11	38	22	7	134	180	489 42.71%
Total	237	75	48	119	43	14	251	358	1145
%	20.70	6.55	4.19	10.39	3.76	1.22	21.92	31.27	

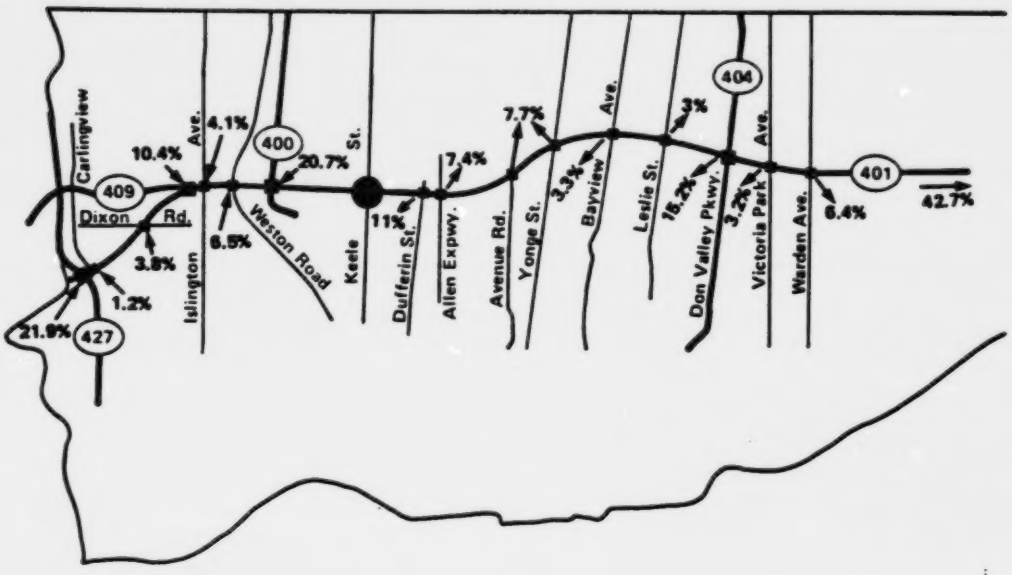


Figure 6/ Schematic of Flows to and From Highway

Table 7/
ENTRY-EXIT PATTERN (WITHOUT FACTORS)
(Core Lanes)

	Hwy 400	Weston Road	Islington	Hwy 409	Dixon Road	Carlingview Drive	Hwy 427	Other	Total %
Dufferin	6	1	2	4	-	1	8	6	28 4.59%
Allen Expressway	2	2	-	2	-	-	3	5	14 2.30%
Avenue, Yonge	6	3	1	6	-	-	4	20	40 6.56%
Bayview	5	2	1	2	1	-	3	6	20 3.28%
Leslie	2	2	1	1	3	-	2	10	21 3.44%
Don Valley/ Highway 404	19	3	5	13	2	3	21	27	93 15.25%
Victoria Park	3	-	-	3	2	-	7	9	24 3.93%
Warden	11	2	-	6	4	-	5	16	44 7.21%
Other	37	10	7	29	15	4	101	123	326 53.44%
Total	91	25	17	66	27	8	154	222	610
%	14.92	4.10	2.79	10.82	4.43	1.31	25.25	36.39	

Caution: It is not possible to enter Dufferin and Allen Expressway from the core lanes.

Table 8/
ENTRY-EXIT PATTERN (WITHOUT FACTORS)
(Collectors)

	Hwy 400	Weston Road	Islington	Hwy 409	Dixon Road	Carlingview Drive	Hwy 427	Other	Total %
Dufferin	22[1]	6[1]	6[1]	15[1]	4[1]	2[1]	21[1]	24[1]	98 18.32%
Allen Expressway	26[1]	6[1]	7[1]	5[1]	3[1]	-[1]	12[1]	12[1]	71 13.27%
Avenue, Yonge	18[2]	3	3	8	-	1	5	10	48 8.97%
Bayview	2[2]	4	-	4	1	-	4	2	17 2.43%
Leslie	3[2]	3	-	1	-	-	3	4	14 2.62%
Don Valley/ Highway 404	27[2]	11	4	6	1	2	13	17	81 15.14%
Victoria Park	3[2]	2	3	2	-	-	2	1	13 2.43%
Warden	7[2]	3	4	3	-	-	4	9	30 5.61%
Other	38[2]	12	4	9	7	3	33	57	163 30.47%
Total	146	50	31	53	16	6	97	136	535
%	27.29	9.35	5.79	9.91	2.99	1.12	18.13	25.42	

NOTES: [1] Must use collectors lanes

[2] May use collector lanes (due to difficult weaving condition)

4.5/ Collector and Core Lane Usage

Core and collector lane usage is partially reflected in Tables 7 and 8. Examination of the entry - exit pattern for the collectors revealed that between 50% and 65% of those trucks could, in fact, have used the faster core lanes (only those vehicles exiting to Dufferin St. or Allen Expressway must use the collector lanes at this point). However, the number of trucks on the three core lanes and the three collector lanes for the duration of the survey was 3712 and 2637, respectively. This may be reduced to 247 and 176 trucks per lane per hour for the core and collectors, respectively. It is quite possible that the differential truck traffic in the two sections of the highway was perceived by truck operators on the collectors to be advantageous.

4.6/ Trip Length Frequency Distribution

Trip length frequency distributions of trucks on the core lanes and collectors are shown in Figures 8 and 9. The weighted mean trip lengths for truck trips on the core lanes are about 50% higher than those on the collectors. The weighted mean trip length for truck trips on the core lanes is about 84 km. This supports the conclusion that the core lanes are being used for longer trips.

Trip length frequency distributions for gasoline-powered trucks and diesel-powered trucks are depicted in Figures 10 and 11. The weighted mean trip length for gasoline-powered trucks is about 53.9 km. This is about half the mean trip length for diesel-fuelled trucks. The diesel-powered trucks are seen to be utilized for longer trips.

4.7/ Trip Distribution Pattern

The trip distribution patterns may be analysed at various levels viz., regional municipality, major planning districts, and study zones.

Truck trip interchanges between regional municipalities are tabulated on the following page.

From \ To	Toronto	Durham	York	Peel	Halton	Ham. Went.	External	Total
Toronto	1522 32.6%	123 2.6%	158 3.4%	-	6	-	166 3.6%	1975 42.3%
Durham	-	-	-		-	-	-	-
York	215 4.6%	20	5	-	-	-	-	240 5.1%
Peel	888 19.0%	121 2.6%	62 1.3%	- -	- -	- -	70 1.5%	1141 24.4%
Halton	217 4.65%	35 -	18 -	- -	6 -	- -	29 0.6%	305 6.5%
Hamilton Wentworth	53 1.1%	30 -	5 -	- -	- -	- -	23 -	111 2.38%
External	562 12.0%	158 3.4%	39 0.8%	-	-	-	134 2.9%	893 19.1%
Total	3457 74.1%	487 10.4%	287 6.1%	- -	12	- -	422 9.0%	4665 -

Percentages are on the total traffic.

Note: Expansion factors have been applied to represent total traffic during the period 10:00 - 15:00.

From the above tabulation it is seen that nearly 84% of the truck traffic has either one end or both trip ends located in Metro Toronto. A detailed breakdown of the trip ends is shown below.

- o Both trip ends in Metro Toronto 32.6%
- o One trip end originating in Toronto 9.7%
- o One trip end destined to Toronto 41.5%
- o Both trip ends outside Metro Toronto 16.2%

The imbalance in the percentages of trips destined to and originating in Toronto occurs because the survey data is confined to the eastbound flow of traffic.

4.8/ Trip Interchanges by Planning Districts

A trip distribution pattern by planning districts gives a disaggregate view of the origins and destinations of truck trips in the TARMS area.

Figure 7 shows the origin and destination of truck trips by Planning Districts.

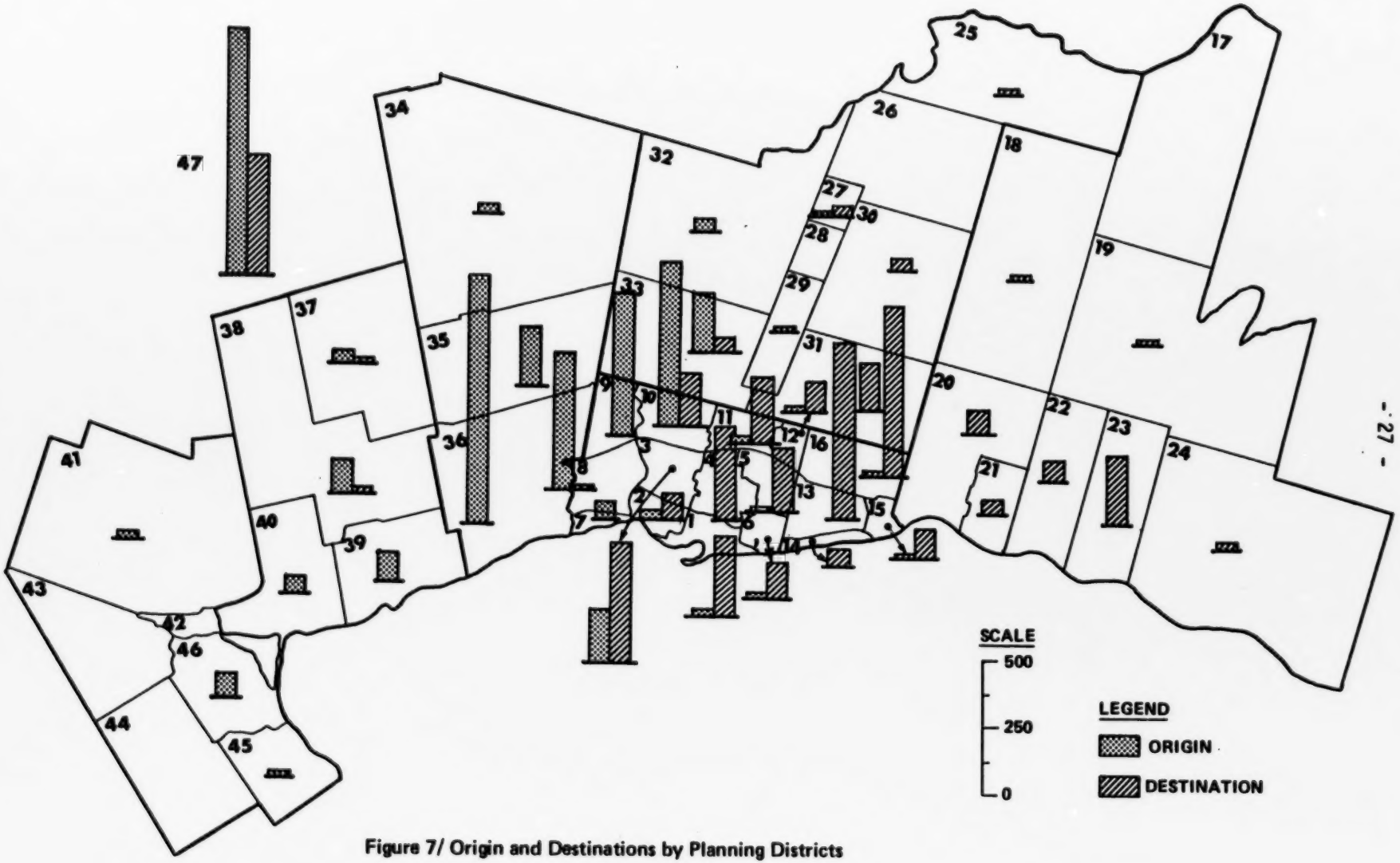


Figure 7/ Origin and Destinations by Planning Districts

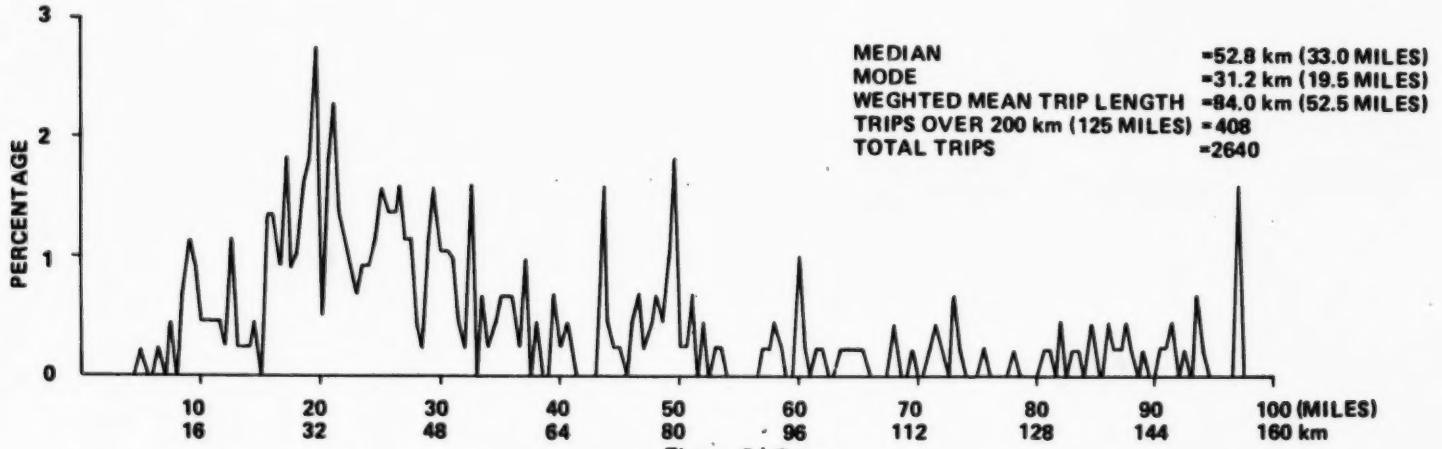

MEDIAN =52.8 km (33.0 MILES)
MODE =31.2 km (19.5 MILES)
WEGHTED MEAN TRIP LENGTH =84.0 km (52.5 MILES)
TRIPS OVER 200 km (125 MILES) =408
TOTAL TRIPS =2640
PERCENTAGE
0
1
2
3
10 20 30 40 50 60 70 80 90 100 (MILES)
16 32 48 64 80 96 112 128 144 160 km

Figure 8/ Core

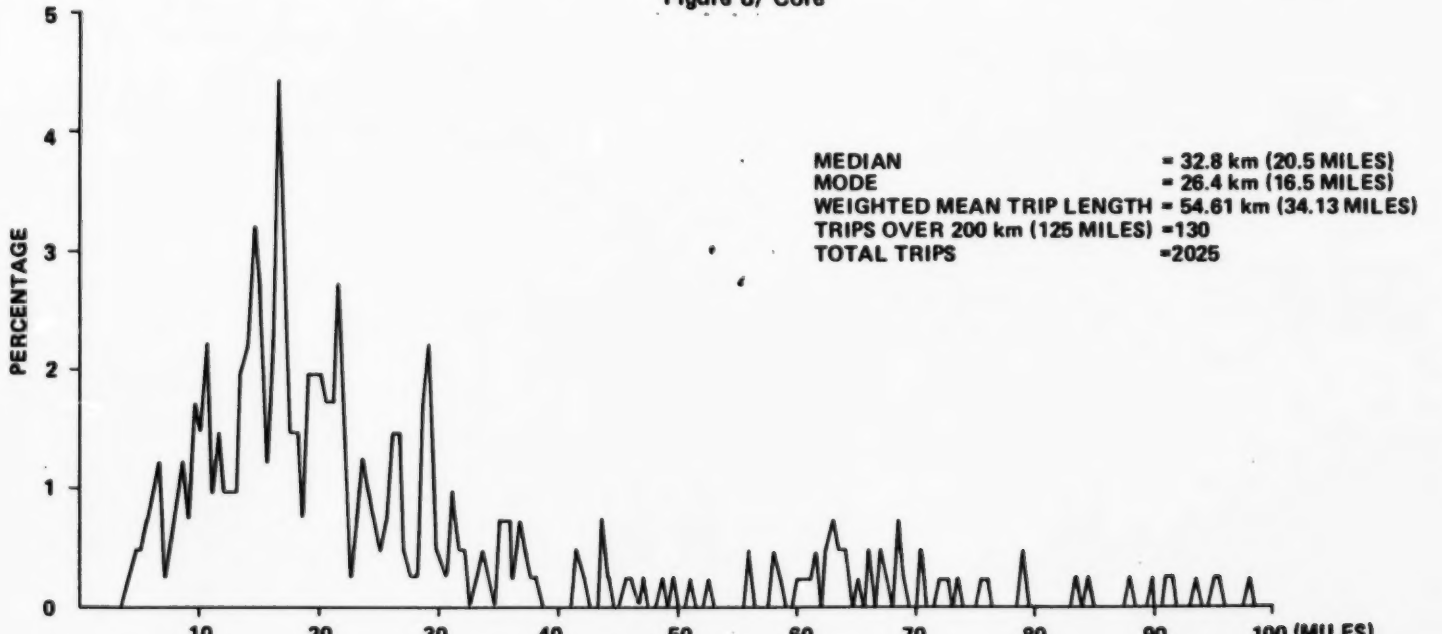

MEDIAN = 32.8 km (20.5 MILES)
MODE = 26.4 km (16.5 MILES)
WEIGHTED MEAN TRIP LENGTH = 54.61 km (34.13 MILES)
TRIPS OVER 200 km (125 MILES) =130
TOTAL TRIPS =2025
PERCENTAGE
0
1
2
3
4
5
10 20 30 40 50 60 70 80 90 100 (MILES)
16 32 48 64 80 96 112 128 144 160 km

Figure 9/ Collector

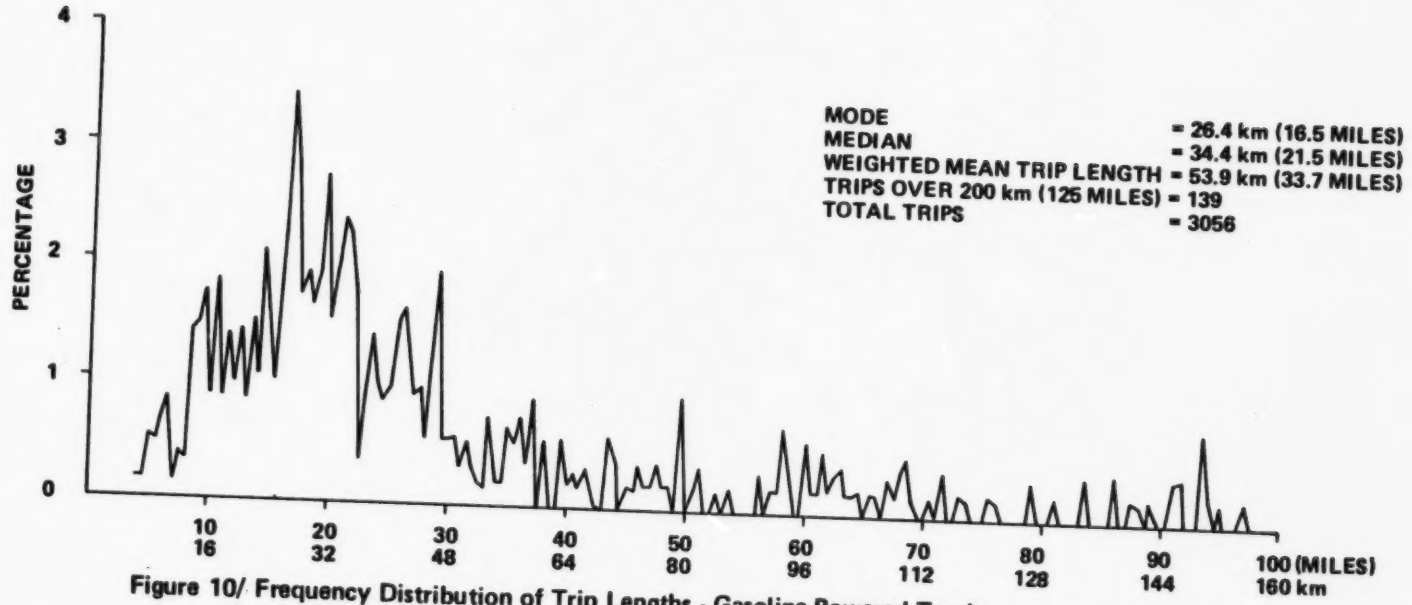


Figure 10/ Frequency Distribution of Trip Lengths - Gasoline Powered Trucks

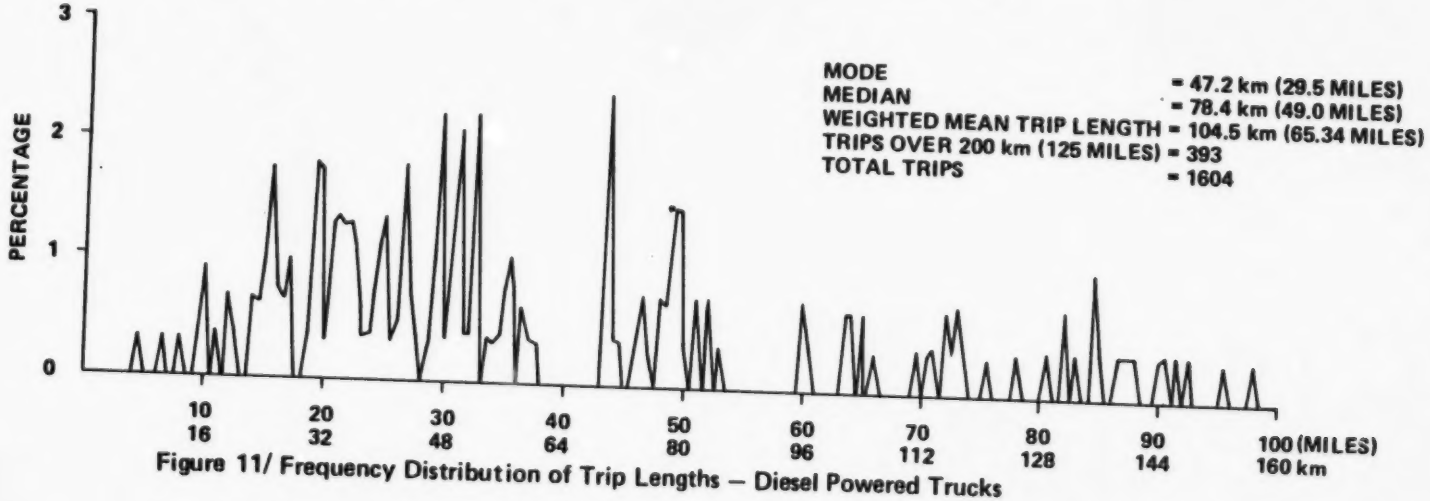


Figure 11/ Frequency Distribution of Trip Lengths – Diesel Powered Trucks

4.9/ Statistical Validity of the Sample

A total of 4506 vehicles passed through the survey station of the four lanes surveyed for the duration of the survey. However, 3357 valid truck licence plates were captured on photographic film and questionnaires were posted to the registered owners of the trucks. This was treated as the survey micropopulation in the absence of a breakdown by body type for the Ontario Truck population. Fully completed codeable questionnaires were received from a sample of 1144 respondents. The question addressed in this section is whether the sample obtained from the survey is representative of the vehicle population.

A breakdown of all vehicles both in the micropopulation and the sample by body type is shown in Table 9. A chi-square test was done to establish whether observed differences among the two distributions are significant or whether they can be attributed to chance. Truck types with five or less in each group were combined with similar types so that the chi-square test might be applied.

We proceeded to test the null hypothesis $p_1 = p_2 = \text{---} = p_8$ (where p is the proportion of each type in the whole) against the alternative that $p_1, p_2, \text{---} p_8$ are not all alike. If the null hypothesis is true we can combine the group samples and estimate the common proportion of persons providing a response to the questionnaires, as 1144/3357 = 0.341. With this estimate we would expect 46 x 0.341 = 15 responses in the Bus and Box trucks, 92 x 0.341 = 31 for Dump trucks, etc. Subtracting these figures from the sizes of the respective sample we would correspondingly expect 46 - 15 = 31, 92 -31 = 61 for the non-respondent category. The results are summarized in Table 9.

To test the null hypothesis a comparison is made between the frequencies that were actually observed and those we could expect if the null hypothesis were true.

TABLE 9/ TRUCK TYPE BREAKDOWN - STATISTICAL VALIDITY

	RESPONDENTS			NON-RESPONDENTS			
TYPE	Observed	Expected	$\frac{(O-E)^2}{E}$	Observed	Expected	$\frac{(O-E)^2}{E}$	TOTAL
Bus & Box	10	15	1.67	36	31	0.81	46
Dump	27	31	0.52	65	61	0.26	92
Flatbed	22	19	0.47	35	38	0.24	57
Pickup	157	167	0.60	333	323	0.30	490
Stake & Tanker	55	43	3.35	71	83	1.73	126
Tractor	472	408	10.04	723	787	5.2	1195
Tow & Van	362	420	8.01	869	811	4.15	1231
Other	22	23	0.04	45	44	0.02	67
None Above	17	18	0.06	36	35	0.03	53
	1144	1144	24.76	2213	2213	12.74	3357

$$\Sigma\frac{(O-E)^2}{E} = 37.5$$

$$8x^2 = 20.09$$

Thus from Table 9 we obtain $x^2 = \frac{\Sigma (O-E)^2}{E} = 37.50$, and since this exceeds 20.09, the value of $8x^20.01$ for 8 degrees of freedom, the null hypothesis must be rejected. This means that there is a significant difference in the response rates among the groups.

Also from Table 9 it can be seen that the contribution to the summed difference from the tractor truck type is highest. Further, the response received from this type is greater than the estimate of expected response. The chi-square test is re-applied excluding this category of trucks.

TABLE 10/ TRUCK TYPE BREAKDOWN EXCLUDING TRACTORS - STATISTICAL VALIDITY

	RESPONDENTS			NON-RESPONDENTS			
TYPE	Observed	Expected	$(O-E)^2/E$	Observed	Expected	$(O-E)^2/E$	TOTAL
Bus & Box	10	14.3	1.29	36	31.6	0.61	46
Dump	27	28.6	0.09	65	63.4	0.04	92
Flatbed	22	17.7	1.04	35	39.3	0.47	57
Pickup	157	152	0.16	333	338	0.07	490
Stake & Tanker	55	39.2	6.37	71	86.8	2.87	126
Tows & Vans	362	382	1.05	869	849	0.47	1231
Other	22	20.8	0.07	45	46.2	0.03	67
None Above	17	16.5	0.02	36	36.5	0.01	53
	672		10.09	1490		4.57	2156

$$\Sigma (O-E)^2/E = 14.66$$

$$7 x^2 0.01 = 18.48$$

Table 10 shows the revised computation of squared differences. This yields $x^2 = \frac{\Sigma (O-E)^2}{E} = 14.66$, and since this is less than the value of $7x^20.01 = 18.48$ the null hypothesis must be accepted. In other words, there is no significant difference in the rates of response between groups when tractor trucks are eliminated from consideration. This hypothesis would be incorrectly accepted less than one percent of the time.

To summarize, excluding tractor truck types where the response has been favourable (better than expected) creates no significant difference in the rates of response between types.

TABLE 11/ BODY STYLE VS. NUMBER OF AXLES FOR YES RESPONSE AND SURVEY POPULATION

	Codeable Response Axles			Survey Population Axles		
	2	3	Total	2	3	Total
Bus	2	2	4	11	5	16
Box	-	6	6	5	25	30
Dump	2	25	27	8	84	92
Flat Bed	3	19	22	11	46	57
Pick Up	148	9	157	459	31	490
Stake	9	38	47	19	96	115
Tanker	1	7	8	2	9	11
Tractor	35	437	472	108	1087	1195
Tow	2	2	4	8	7	15
Van	203	155	358	784	432	1216
Other	5	17	22	8	59	67
None Above	5	13	17	21	32	53
	414	730	1145	1444	1913	3357
	36.2%	63.8%	100%	43%	57%	100%

4.IO/ Composition of Truck Population by Axle Types

A stratification of the survey population and the codeable responses by number of axles and body styles is depicted in Table 11.

The proportion of two axles to three axles in the survey population is about 43:57 (approximately 3:4). However, in the codeable response category it is noted that this mix is 36:64 (about 9:16). This indicates that the response from 3-axle types - generally the heavier and more powerful units - is higher than that of the two axle category.

It may be mentioned here that only data pertaining to the power unit have been recorded in the Master Vehicle File, even though the power unit may be used to tow a trailer with an axle arrangement of more than three axles. To that extent this information is of limited use.

In any subsequent survey it is suggested that the axle arrangement of trucks be shown in pictorial form so that respondents could check one type as was done in the Boston survey (1) 1968.

(1) Howard McCann and Gary Maring, Licence Plate Traffic Survey, Highway Research Record, Highway Research Board No 297 pp. 68-78.

5/ CONCLUSIONS AND RECOMMENDATIONS

5.1/ Conclusions

This study has attempted to apply the photo licence plate trace technique to study truck travel patterns. The major findings of this study are summarized below.

- o There exists a need for imprinting the station number (lane number) and time of exposure (hour of the day) on each picture frame showing a licence plate. The required modification to the camera has been initiated by the Traffic Characteristics Office and is on hand now.

- o Keyunching errors of the licence plates were about 4%. Review of film and verification of the keypunched cards yield an additional 8%. Considering that verifying the cards takes about as much time as straight keypunching from film the extra work effort is not considered worthwhile. Increased care and caution exercised by the data transfer personnel when keypunching the licence plates from the film could yield better results.

- o The overall response rate of about 50% indicates the degree of truck owner willingness to co-operate in this type of survey. Favourable comments, feedback, and suggestions for improvements from some respondents gives one the feeling that it was a worthwhile exercise in public participation.

- o The usefulness of a question asking for a listing of intermediate stops is in doubt if the stops are not listed in the right sequence. A sample study of questionnaires revealed criss-crossing, which leads one to conclude that the respondents listed the stops without regard to order or time sequence.

- o In the truck population through this station vans, tractor trucks, and pick-up trucks are the most numerous by body styles (in descending order). The relative percentages for each group are 36.2%, 35.6% and 14.6%, respectively.

- o A chi-square analysis showed that excluding tractor trucks where the response has been better than expected made no significant difference in the rates of response between different types at the 0.01 confidence level.

- o Mix of gasoline to diesel powered trucks in the survey population is about 7:3. It is indicated that the diesel truck owners have a higher propensity to respond to a questionnaire. In fact the ratio of response rates from diesel powered truck owners to those of gasoline powered truck owners is 2:1.

- o Stratification by number of axles was of limited use mainly due to the way this information is recorded. However, considering the mix of 2-axle and 3-axle trucks in the survey population a higher response from 3-axle truck owners has been recorded.

- o The weighted mean trip lengths for truck trips on the core lanes are about 50% more than those on the collectors (54.6 km). True to form the core lanes are being used for longer trips.

- o The weighted mean trip length for gasoline-powered trucks is 53.9 km, which is about half that for diesel powered trucks. This indicates that diesel-powered trucks are utilized on longer trips.

- o Nearly 84% of the eastbound truck trips on Highway 401 passing Keele Street have either one end or both trip ends in Metro Toronto.

5.2/ Recommendations

This study indicates that the photo licence plate trace technique is a feasible method of obtaining origin-destination information relating to commercial vehicles using high speed, multi-lane highway facilities. Undoubtedly some areas of this technique may have to be supplemented, and further research and in-depth study is required.

5.3/ Suggestions for Further Research

Kodak Cine - Special 16mm motion picture cameras have been used for filming traffic for licence plate traffic surveys elsewhere. An attempt was made to use a Video Camera to record traffic in a similar way. Instant replay of the recorded pictures over a T.V. is possible although the pictures are not too clear and the resolution of the licence plate is not good.

5.4/ Additional Comments

In restaging a survey of this type special consideration needs to be given to the question of obtaining data for vehicles registered or operated by leasing and private companies. It has been suggested by the Ontario Trucking Association that the questionnaires be predelivered to the major leasing and private companies ahead of the survey date. If the vehicle is expected to pass any of the survey locations the dispatcher may be requested to complete the questionnaire for each such trip.

APPENDIX A

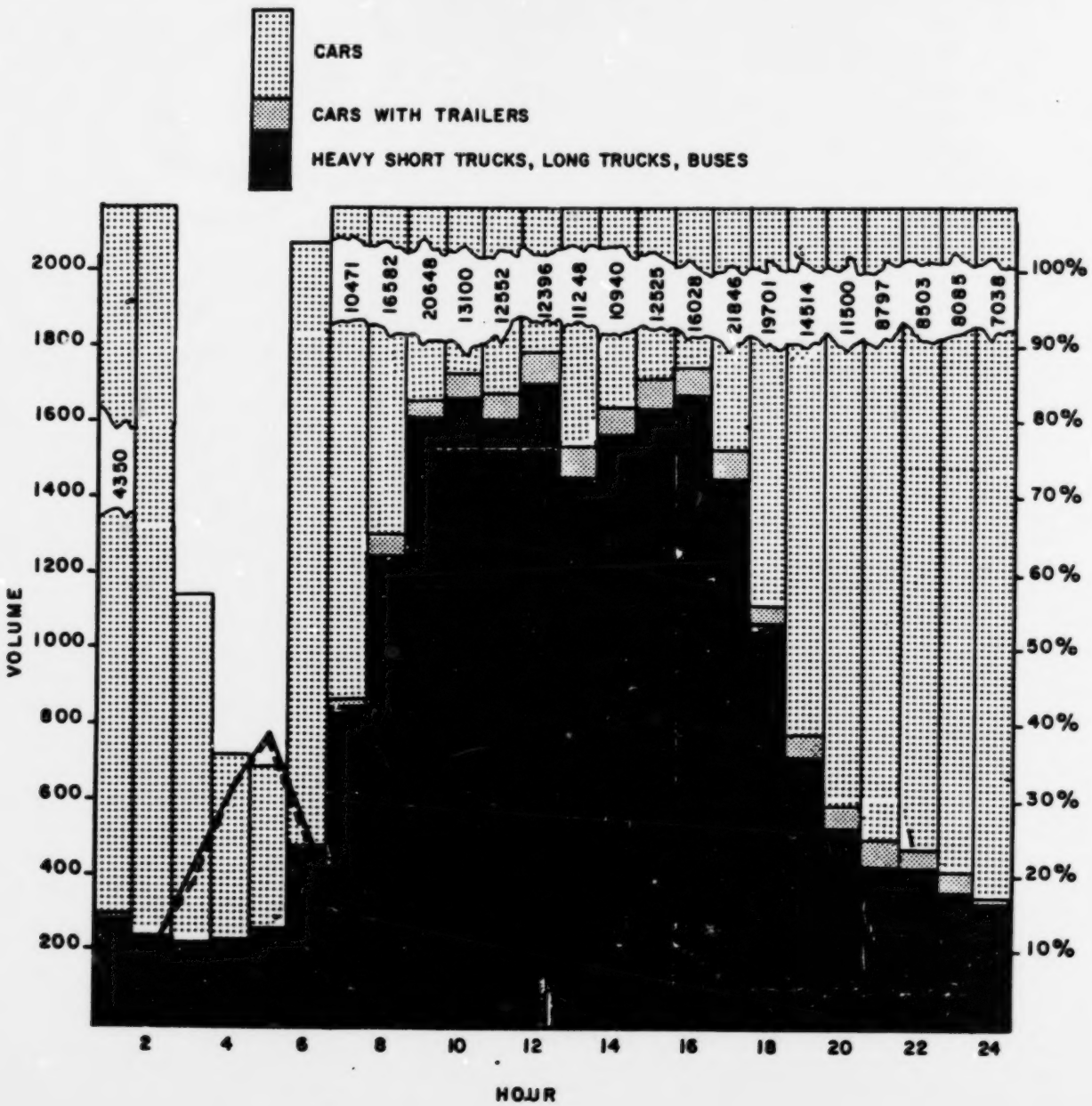
HOURLY DISTRIBUTION

P.C.S. No. 75 P.C.S. NAME KEELE

DATE OF SURVEY 1978 - 06 - 28 DAY WEDNESDAY DIR. COMBINED

——— % (HEAVY SHORT TRUCKS, LONG TRUCKS, BUSES & CARS WITH TRAILERS)

– – – – – – % (HEAVY SHORT TRUCKS, LONG TRUCKS & BUSES)



APPENDIX B

Ministry of
Transportation and
Communications
Ontario

Dear Sir or Madam:

The Ministry of Transportation and Communications is conducting a traffic survey to establish travel characteristics on the Provincial transportation network. This is a routine traffic survey used for monitoring changing traffic conditions. We request your co-operation in providing information which is essential for planning improved transportation services.

Your assistance, by completing the following questionnaire and returning it as soon as possible, will be greatly appreciated. No postage is required.

YOUR ANSWERS WILL BE TREATED IN THE STRICTEST CONFIDENCE. IF YOU FEEL THAT YOU DO NOT WANT TO ANSWER ANY OR ALL OF THE QUESTIONS, PLEASE RETURN THE QUESTIONNAIRE.

Thank you for your assistance and co-operation.

Yours truly,

Ian C. Campbell

I. C. CAMPBELL
Executive Director
Policy Planning and Research Division.

APPENDIX C

Ministry of Transportation and Communications
Ontario

PUBLIC PARTICIPATION IN PLANNING – TRAFFIC SURVEY

MTC USE ONLY

1. WAS VEHICLE NUMBER .....ON HIGHWAY 401 IN THE VICINITY OF KEELE STREET ON NOV 2 0 1980 ? Yes ☐ No ☐

IF NO, PLEASE RETURN THE QUESTIONNAIRE WITHOUT ANSWERING THE REMAINING QUESTIONS.
THANK YOU FOR YOUR COOPERATION.

2. WAS THE VEHICLE, For-Hire ☐ Private ☐

3. WHAT WAS THE INITIAL START (ORIGIN) OF THAT RUN?

City/Town .....

Address for nearest major intersection or name of warehouse) .....

.....

.....

4. IF IT IS A PEDDLE RUN (ROUTE WITH SEVERAL DELIVERY AND PICK-UP STOPS) LIST INTERMEDIATE STOPS.

.....

.....

.....

.....

.....

.....

5. WHAT WAS THE FURTHEST DESTINATION OF THAT RUN?

City/Town .....

Address (or nearest major intersection or name of warehouse) .....

.....

.....

6. AT WHAT INTERCHANGE DID YOU ENTER HIGHWAY 401 EASTBOUND?

Highway 401	☐	Carlingview	☐
Weston Road	☐	Highway 409	☐
Islington	☐	Highway 427	☐
Dixon Road	☐	Other	☐

7. AT WHAT INTERCHANGE DID YOU EXIT HIGHWAY 401 EASTBOUND?

Dufferin	☐	Don Valley	☐
Allen Expwy.	☐	Victoria Park	☐
Avenue Rd., Yonge St.	☐	Warden	☐
Bayview	☐	Other	☐
Leslie	☐		

THANK YOU FOR PARTICIPATING IN THIS SURVEY, PLEASE ADD ANY COMMENTS ON THE BACK OF THIS PAGE.

Appendix D

Weather Conditions - November 25-26, 1980 - Downsview Area

	November 25	November 26
1. Precipitation	Light, snow shower	Nil
2. Sky Condition	Scattered clouds at 2500 - 24 000 feet above ground	Scattered clouds at 1100 - 1600 feet above ground.
3. Cloud Amount	10 - 20% of sky obscured	80 - 100% of sky obscured
4. Cloud Type	Altocumulus changing to Arrus	Mix of Cumulus Fractus and Stratocumulus
5. Visibility	15 miles or more	2 - 8 miles variable
6. Temperature	Max. -3.6°C Min. -4.0°C	Max. -1.3°C Min. -2.5°C
7. Wind Speed (Direction)	6 - 10 knots (SW - W)	10 - 13 knots (NW)

Source: Surface Weather Record - Environment Canada.

APPENDIX E

Coding Instructions

Card Column

Card Column	Item	Code
1 - 5	Record Number	Consecutive
6	Card Type 1	1
7	Lane Number 1 - 4	1 - 4
8	Blank	
9 - 11	Study No.	180
12	Direction	3
13 - 16	Time (24-hour clock)	1000
17 - 22	Day, Month, Year	261180
23 - 28	Licence plate No.	
29	Yes = 1 No = 2 Neither = 3	
30	For Hire = 1 Private = 2 Neither or Blank = 3	
31 - 40	Origin Provincial and Tarms 1979 Zones	
41 - 50	Intermediate Stops	Same as above
51 - 60	" " "	" " "
61 - 70	" " "	" " "
71 - 80	" " "	" " "
1 - 5	Record Number	Copied from Card 1
6	Card Type 2	2
7 - 16	Intermediate Stops	Same as for Origin
17 - 26	" " "	" " "
27 - 30	Destination	" " "

37	Hwy. 400	= 1	Carlingview	= 5	
	Weston Rd.	= 2	Hwy. 409	= 6	
	Islington	= 3	Hwy. 427	= 7	
	Dixon Rd.	= 4	Other	= 8	
38	Dufferin	= 1	Don Valley	= 6	
	Allen Expwy	= 2	Victoria Park	= 7	
	Avenue Rd.	= 3	Warden	= 8	
	Yonge St.	= 3	Other	= 9	
	Bayview	= 4			
	Leslie	= 5			

A) If no street address or intersection is given use general Toronto or Borough #'s.

B) For External Tarms Area use General P.T.Z.

C) Locations in

Western	NY code as	1319
Eastern	NY	1318
Western	USA	1320
Western	Canada	1321
Quebec		1316
Maine		1317

APPENDIX F

Body Style - Commercial Vehicles

2 ALPHA CHARACTERS SIGNIFYING THE BODY STYLE OF A COMM. VEHICLE

1 = BU BUS
SCHOOL BUS

2 = BX BOX
BEVERAGE

3 = DP DUMP

4 = FB FLATBED
DECK
FLAT
PLATFORM

5 = PK PICKUP
CAMPER

6 = ST STAKE
RACK

7 = TK TANKER

8 = TT TRACTOR
CAB
CAB & CHASSIS
CAB OVER ENGINE

9 = TW TOW TRUCK
WINCH
WRECKER

10 = VN VAN
LUNCHWAGON

11 = OC OTHER COMMERCIAL (OTHER COMM)
AERIAL LADDER
AMBULANCE
ARMOURED
BUCKET
CONCRETE MIXER
CRANE
DIGGER
DRILLER
FIRE
GARBAGE
GLASS RACK
HEARSE
LOADER
LOGGING
PACKER
PALLER
RESCUE
SEWER FLUSHER
SHOVEL
SNOW PLOW
SWEEPER
WELDER

12 = NONE OF THE ABOVE

Note: Numeric equivalents are shown in figures

MOTIVE POWER

1 - ELECTRIC

2 - GAS

3 - PROPANE

4 - STEAM

5 - DIESEL